ELECTRONIC DEVICES

CROSS-REFERENCE TO RELATED APPLICATIONS

[0001] The present invention claims priority to European Application Number 02009742.4, "Electronic Devices", filed on Apr. 30, 2002, now abandoned. The EP application is herein incorporated by reference in its entirety.

FIELD OF THE INVENTION

[0002] The present invention generally relates to electronic devices and particularly relates to electronic devices based on fullerenes and method of making such devices.

BACKGROUND OF THE INVENTION

[0003] Ultra-small electronic devices on the nanometer have been the subject of considerable exploratory research. For example, U.S. Pat. No. 5,331,183 describes heterojunctions, diodes, photodiodes, and photovoltaic cells each based on a junction between a conjugated polymer and a fullerene, such as Buckminsterfullerene, C60. The polymer forms a p-type semiconductive donor layer and the fullerene forms an n-type semiconductive acceptor layer. Charge separation in the junction occurs on illumination of the junction.

SUMMARY OF THE INVENTION

[0004] In accordance with the present invention, there is now provided an electronic device comprising a junction formed between a first fullerene layer having a first doping concentration and a second fullerene layer having a second doping concentration different from the first doping concentration.

[0005] The first doping concentration may be zero. The second fullerene layer may be a monolayer. Similarly, the first fullerene layer may be a monolayer. The second fullerene layer may comprise an electron donor dopant such as an alkali metal. The second doping concentration may be in the region of 10^{21} per cm^3. In a preferred embodiment of the present invention, the device is in the form of a diode wherein the first fullerene layer is connected to an anode and the second fullerene layer is connected to a cathode. In another preferred embodiment of the present invention, the device is in the form of a field effect transistor wherein the first fullerene layer serves as a gate region and the second fullerene layer serves as a channel region extending between a source terminal and a drain terminal. The second fullerene layer may alternatively comprise an electron acceptor dopant. At least one of the first and second fullerene layers may be formed from C60. It should be appreciated that at least one of the first and second fullerene layers may consist of a single bucky ball.

[0006] Viewing the present invention from another aspect, there is now provided, a method for fabricating an electronic device comprising forming a junction between a first fullerene layer having a first doping concentration and a second fullerene layer having a second doping concentration different from the first doping concentration.

[0007] In a preferred embodiment of the present invention, there is provided a semiconductor/metal combination. By varying the ratio between the semiconductor and the metal, the electrical properties of the device can be adjusted. No illumination is needed to render the device operable.

[0008] Preferred embodiments of the present invention will now be described, by way of example only, with reference to the accompanying drawings, in which:

BRIEF DESCRIPTION OF THE DRAWINGS

[0009] **FIG. 1** is a cross sectional view of a diode embodying the present invention;

[0010] **FIG. 2** is a cross sectional view of a junction field effect transistor embodying the present invention;

[0011] **FIG. 3** is a cross sectional view of another junction field effect transistor embodying the present invention;

[0012] **FIG. 4** is a plan view of another junction field effect transistor embodying the present invention;

[0013] **FIG. 5** is a cross sectional view of a junction diode embodying the present invention;

[0014] **FIG. 6** is a cross sectional view of a C60/Au(110) junction;

[0015] **FIG. 7** is an I/V characteristic curve corresponding to the C60/Au(110) junction;

[0016] **FIG. 8** is a cross sectional view of a Li@C60/Au(110) junction;

[0017] **FIG. 9** is an I/V characteristic curve corresponding to the Li@C60/Au(110) junction; and,

[0018] **FIG. 10** is an I/V characteristic curve corresponding to the **FIG. 1** diode when constituted by an Li@C60/C60/Au(110) junction.

DETAILED DESCRIPTION OF THE INVENTION

[0019] Preferred embodiments of the present invention to be described shortly include nanometer sized structures that operate as elements for electronic circuits on the nanometer scale. The structures described by way of example are based on combinations of fullerenes in pure form with fullerenes doped with a metal. In particularly preferred embodiments of the present invention, doped exohedral and endohedral fullerenes such as Li@C60 and La@C82 are employed. Other embodiments of the present invention may include both semiconducting and/or metallic carbon nanotubes. The present invention advantageously facilitates the fabrication of circuit elements on a 1 nm scale because the typical length scale in fullerenes is 0.7 nm, which is the diameter of a single bucky ball.

[0020] Referring first to **FIG. 1**, in a preferred embodiment of the present invention, there is provided a Schottky diode comprising an undoped fullerene layer **2** and a doped fullerene layer **3** on a metal substrate **1**, with the undoped fullerene layer **2** disposed between the metal substrate **1** and the doped fullerene layer **3**. The substrate **1** is formed from Au(110). The undoped fullerene layer **2** is a two molecule thick layer of C60. Experimental results to be described shortly demonstrate that C60 is semiconducting. The doped fullerene layer **3** is a 1 molecule thick layer of lithium doped C60 (Li@C60). One molecule thick layers are usually and will hereinafter be referred to as monolayers.